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Monterey, California

THESIS

PHYSICIAN SUPPLY: AN ECONOMETRIC APPROACH

by

William C. Mackey, III

and

Robert E. Wiltrout, III

March 1975

Thesis Advisor: M. K. Block
D. R. Whipple

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Physician Supply: An Econometric Approach

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A model explaining physician supply in the United States from 1953 to 1973 was postulated and estimated. Factors affecting the supply of foreign and domestic physicians were examined separately. Several aspects of medical school capacity and physicians' income were also developed, and recent trends in medical education and the training and licensing of physicians were examined. A model for examining the selection of medical specialties was proposed.

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I. INTRODUCTION

The advent of the All Volunteer Force has had a significant impact on the projected ability of the military services to recruit and retain physicians in numbers sufficient to operate the military health care delivery system at its historical level. Thus more attention must and is being given to the quantification of those elements which affect the flow of new physicians into active practice in the United States. This is a necessary first step in constructing a model which would assist the services with their particular physician problem.[1]

Pierce Johnson, after reviewing the literature and examining the historical production of physicians since 1910, prepared a model to explain physician supply [Ref. 1]. Using Johnson's work as a basis, a more refined model was developed and estimated using data from 1950 to 1973.

Focusing on the monetary aspects of students' decisions to enter the field of medicine, a series of equations was estimated that explains the yearly production of domestic physicians. In addition, a set of structural equations was formulated, but not estimated, which might describe the economic factors influencing a medical student in his choice of a specialty.

---

[1] This research is a portion of a project being funded by Systems Analysis Division, Office of the Chief of Naval Operations, examining physician supply.

The elements which determine the flow of foreign trained physicians into the United States health care delivery system were examined and modeled. Finally, the existence of barriers which prevent foreign physicians from practicing in this country was addressed.

II. THE MODEL

The supply of physicians entering the medical profession in a given year (or accessions in year t) comes from two sources; they may either be graduates of domestic or foreign medical schools. In equation form, accessions are defined in year t (A_t) as:

$$A_t \equiv FMGL_t + DMGL_t \qquad (1)$$

where $FMGL_t$ represents foreign-trained physicians licensed for practice in the U.S. in year t and DMGL is their domestic counterpart. Their respective paths entering the system are quite different, and must therefore be considered separately.

A foreign medical graduate (FMG) desiring to practice medicine in the United States faces certain obstacles before he may apply for licensure. He must first pass the Education Council on Foreign Medical Graduates (ECFMG) examination. The annual failure rate in this examination is high, and greatly restricts the number of foreign physicians eligible to seek licensure in the U.S. Yet the financial benefits of becoming a licensed physician in this country are substantial.

In the present model, the number of foreign medical graduates who have applied for but not yet passed the ECFMG exam will be designated by the variable POOL, inasmuch as

they literally represent a pool of potential licensed physicians available to this country. POOL is assumed to be a function of the net median income of a U.S. physician (INCOME), and the historical probability of successfully passing the ECFMG exam (PASS). This relation can be represented in general form by:

$$POOL_t = f(INCOME_{t-x}, PASS_{t-x})^2 \qquad (2)$$

Once a member of the POOL has successfully completed the ECFMG exam, he is eligible to seek licensure in the state in which he desires to practice. However, requirements for the licensure of foreign medical graduates vary greatly from state to state. Since a substantial portion of these doctors never become licensed physicians, the number of foreign medical graduates actually licensed to practice in the U.S. (FMGL) is modeled as a function of POOL.

$$FMGL_t = g(POOL_{t-x}) \qquad (3)$$

---

[2] In this and in all subsequent equations, the subscripts represent time in increments of one year. Given that time t is the year being examined, a subscript of t-x is the value of that variable x years earlier, reflecting a delay (or a "lag") of x years before the impact of a change in the independent variable (in this case INCOME) would be reflected in the dependent variable (POOL, for instance). This period is normally interpreted as a delay in the flow of information, or the period of time that passes before this information becomes a basis for decision. The exact value of these time lags, for each equation to be examined, will be specified in subsequent chapters.

The number of domestic medical school graduates can be modeled in more detail. A student who has completed four years of college may apply to medical school. Undoubtedly many of these applicants are motivated by highly personal or idealistic goals, and would seek to become physicians at almost any income level. Nonetheless, most applicants may be presumed to be influenced, to a significant extent, by the previously discussed variable INCOME, and the amount of federal scholarships and loans available to medical students (FSL). Thus the number of applicants can be described by the equation:

$$\mathrm{APPLICANTS}_t = h(\mathrm{INCOME}_{t-x}, \mathrm{FSL}_{t-x}) \qquad (4)$$

It is necessary to note that medical schools in this country have been operating at capacity for the time period covered by this model.[3] In their annual report on medical education, the Journal of the American Medical Association has used identical figures for "enrolled students" and "capacity" since 1950. The question then becomes, "What affects capacity?"

Previous studies have claimed that the capacity of medical schools is dictated by the American Medical Association in accordance with their own self-interest,

---

[3] For purposes of this model "capacity" will refer only to the capacity for first-year enrollment, and not the total capacity of the school.

and perhaps this is so.[4] This model is not structured to examine this hypothesis directly. Identifying (and quantifying) this type of influence would be extremely difficult, and would require a separate analysis. But other factors presumably exist which should exert substantial influence on the decision to expand or reduce capacity. Certain federal legislative incentives (FLI) to increase capacity may well have had an effect.[5] The demand for increased capacity, as reflected by applicants, should also be significant. Certainly if it can be demonstrated that these factors exerted only a nominal influence on the overall capacity, such results would be consistent with the hypothesis that a strong external constraint to limit the growth of medical schools does exist. Whether or not this constraint might have been imposed by the AMA would, of course, not be discernable within this model.

We will examine the following relationship between capacity, applicants, and legislative incentives:

$$CAP_t = m(APPLICANTS_{t-x}, FLI_{t-x}) \qquad (5)$$

---

[4] Self-interest in the sense that a shortage in physician supply in the U.S. drives up the price for physician services, manufacturing artificially high salaries for the member physicians. For an examination of these studies, see Reference 1.

[5] State legislative incentives might be even more significant, particularly for state institutions, but modeling this would require an examination of the capacity of each of the medical schools individually, an effort far beyond the scope of this research.

The number of students actually graduating from medical school (GS) will be defined as the number of students entering medical school minus an attrition factor. Studies have shown that the principal cause of attrition among medical school students has been academic failure, followed by a loss of desire to become a doctor. Lack of financial support appeared to be rarely a problem [Ref. 2]. It will be assumed that the percentage of entering students graduating four years later is a constant factor k. Moreover, since capacity is identical to the number of entering students, we can define GS to be:

$$GS_t = k * CAP_{t-4} \qquad (6)$$

It should be noted that graduating from a domestic medical school does not imply automatic licensure. Each graduate must complete a specified period of residency before he is eligible for licensure, the time required being dependent on the particular medical specialty he desires to enter.

In previous years, this period was separated into a one-year generalized "internship," with a subsequent two or more years of specialized "residency." But the current trend in medical education is for graduates to go directly from medical school into residencies, with internships being completely phased out in the near future.[6] In

---

[6] See discussion in Chapter III.

this model periods of internship and residency will be combined under the term "residency."

Attrition during this period has not been examined in the literature, but it appears that almost all domestic medical school graduates are licensed at some time subsequent to graduation. In fact, the American Medical Association, in its annual Distribution of Physicians in the United States has included interns and residents as a part of the total physician strength of the United States. Thus the equation for the licensure of a domestic medical graduate will not be examined in detail, but rather presumed to be a mechanical relationship represented by the equation:

$$DMGL_t = n * GS_{t-x}, \quad 0 < n < 1 \qquad (7)$$

The formal model is now complete, inasmuch as the sum of DMGL and FMGL is the annual accessions to the medical profession, as discussed in equation (1). But A_t can also be defined as the summation of physicians entering each of the medical specialties.[7] Consider the equation:

$$A_t = \sum_{i=1}^{6} EP_t^{\,i} \qquad (1a)$$

---

[7] For this equation, the corresponding values for i will be 1 - General Practice; 2 - Internal Medicine; 3 - General Surgery; 4 - Obstetrics/Gynecology; 5 - Pediatrics; 6 - All Other.

What factors influence a young physician in this decision process? One might be the opportunity cost (OC^i) in choosing specialty i instead of specialty j, where j represents the specialty having the greatest financial return. Given the nature of this market, the job opportunity (JO) or the need for more specialists of type i might also have an effect. This is the case because the availability of residencies within a field and the opportunities to practice in that field after licensure would probably influence the individual's decision. Thus the number of physicians entering each specialty may be modeled as:

$$EP_t^i = fi(OC_{t-x_i}^i, JO_{t-x_i}^i) \qquad (8)$$

with $OC_{t-x_i}^i$ determined by the difference in median incomes in year $t-x_i$, and $JO_{t-x_i}^i$ defined as the percentage of residencies filled in specialty i in year $t-x_i$, the interval x_i varying according to specialty.

III. THE DOMESTIC PHYSICIAN

While the foreign trained physician represents the short-run supply response (see Chapter IV) to changes in needs or demands for physicians, the model postulates the domestically trained physician as the long-run supply response. That is, the number of physicians that can be produced (trained) at any given point in time is constrained by the capacity of United States medical schools at that time. In order to increase this capacity, existing facilities must be expanded or new facilities constructed. Qualified personnel must be found to administer and teach in these facilities. After the initial decision to expand, construction takes the majority of the time before new facilities can be put into use. Moreover, even if construction were instantaneous, it would still require a minimum of three years for any student to successfully complete his education in the new facility.[8]

Upon completion of medical school, the graduates are not yet able to practice. They must be licensed by one of the individual states or the national licensing board. This requires passing a written examination and completion of a year of internship/residency. The minimum amount of time

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[8] A medical school education would normally take four years. However, under the Health Manpower Training Act of 1971, special incentives are provided to reduce the length of training, and a significant number of three-year graduates are now being produced.

from the opening of a new medical school until its first graduates become licensed physicians available to practice is thus a minimum of four years.

A. FACTORS AFFECTING CAPACITY OF AMERICAN MEDICAL SCHOOLS

During the period examined there has been a surplus of applicants for medical school (see Table 1). It appears that the binding constraint is not the lack of qualified applicants.

While perhaps a decade ago medical school administrators had argued that the number of qualified applicants was insufficient to justify any substantial expansion, this is certainly not true today. The academic profile of the rejected applicant has improved considerably. Pressure to accept students of minority groups has resulted in applicants who would probably have been considered unqualified being accepted, and their subsequent satisfactory performance and graduation is a strong indication that the large number of better qualified non-minority applicants rejected by medical schools could reasonably be expected to support any expansion. Only in those state-supported medical schools that are required to accept a set quota of resident applicants could the availability of applicants be a real constraint [Ref. 17].

Instead, the capacity of existing medical schools appears to be the binding constraint, and for the purposes of this model, it was assumed that all medical schools

TABLE I

MEDICAL SCHOOL ACCEPTANCE RATES

1950-1972

Academic Year	Applicants	Acceptances	Acceptance Rate
1950-51	22,279	7,254	32.6
1951-52	19,920	7,663	38.5
1952-53	16,763	7,778	46.4
1953-54	14,768	7,756	52.8
1954-55	14,538	7,878	54.2
1955-56	14,937	7,969	53.4
1956-57	15,917	8,263	51.9
1957-58	15,791	8,302	52.6
1958-59	15,170	8,366	55.1
1959-60	14,952	8,512	56.9
1960-61	14,397	8,560	59.9
1961-62	14,381	8,682	60.4
1962-63	15,847	8,959	56.5
1963-64	17,668	9,063	51.3
1964-65	19,168	9,043	47.2
1965-66	18,703	9,012	48.2
1966-67	18,250	9,123	50.0
1967-68	18,724	9,702	51.8
1968-69	21,117	10,092	47.8
1969-70	24,465	10,514	43.0
1970-71	24,987	11,500	46.0
1971-72	29,172	12,335	42.3
1972-73	36,135	13,757	38.1

Source: Reference 3, page 909.

are operating at full capacity. Rather than defining capacity as the total enrollment in medical schools, it is defined as the number of first-year openings. That is:

$$CAP_t \equiv ES_t$$

It is at this point in the system that increases (or decreases) will first become noticeable.

1. Applicants

The number of applicants applying for medical school in a given year represent the pressure of those outside the medical profession desiring entry. It is assumed that this pressure is not considered relevant for capacity decisions if it is transitory. As a consequence the model has been designed to evaluate the effect of applicant pressure over an extended period of time. To reflect this pressure for expansion, the model uses the sum of applicants over the last three years under the variable name CANTS3, where

$$CANTS3 = \sum_{i=t-2}^{t} APPLICANTS_i$$

2. Federal Incentives for Increasing First Year Enrollments

The variable FLI represents the total federal obligations to medical schools in the area of undergraduate medical education, including loans, scholarships, operating funds, and construction funds for teaching and research

facilities. The first legislation to make a substantive impact in this area was the Health Professions Educational Assistance Act (HPEA) of 1963, and the resultant contributions to medical education showed a marked increase beginning in 1965 and continuing to the present (see Appendix A, Table XII). As a consequence, two variables were used, with MINFLI representing the relatively minor obligations from 1950 to 1964, and MAJFLI representing the increasing obligations from 1965 to the present.

This division enables one to distinguish between generalized federal funding, offered to a wide variety of educational institutions which happened to encompass medical schools, and the concentrated efforts of the federal government to stimulate the growth and development of schools of medicine.

These efforts have been substantial [Ref. 4]. The HPEA offered federal financing for up to two-thirds of all new construction or renovation done with the intent of increasing the capacity of a school of medicine, and initiated a program of scholarships for medical students. In 1965 it was amended to implement the scholarship proposals, and included an authorization to provide federal support for operating costs and such improvements as were necessary to strengthen the accreditation status of schools having difficulty in this area.

In 1968, the Health Manpower Act extended the provisions of the HPEA Act, and established the Bureau of

Health Professions Education to administer the Physician Augmentation Program, a program designed to increase first-year enrollments (defined as CAPACITY by the model) by 1,000 students by 1970 [Ref. 5]. The award of any basic improvement grants was predicated upon an enrollment increase of at least five students, or 2.5% of the first-year class if the enrollment already exceeded 200 students. This act also established the priorities of increased enrollment, financial distress, curriculum improvement, and reduced period of training.

In 1971, the Comprehensive Health Manpower Training ACT (CHMTA) shifted the emphasis to a program of "first-dollar" capitation grants, providing $6,000 per graduate to any school increasing its initial enrollment by 10 students (or 5%, if enrollment exceeded 200 students). Scholarships were incorporated into the Federal Guaranteed Student Loan Program, and these funds were now distributed among the schools on the basis of the number of enrolled students from low-income families rather than total enrollment, an attempt to stimulate minority selection. To encourage a shortened period of education, additional awards were provided for each student graduating in three years, or completing a combined six-year program of pre-med and medical school. A separate source of funds was established for schools of medicine opening after 18 November 1971, with a sliding scale from $10,000 initially to $2,500 at the end of the third year for each student enrolled in the

school. The federal share of financing construction was increased to 80% for new schools or major expansions of existing schools, and 70% for all other.

The increased funding due to this major effort can be observed in Appendix A, Table X, and the effect of these funds as shown by the elasticity is discussed in the next section. While other pressures may have encouraged expansion to some extent, the magnitude of the increase in the late 1960's contrasts sharply with the growth in prior years. Perhaps the most telling fact is the major jump in the 1972-73 enrollment figure. At a time when the 1968 act had already brought about substantial expansion, and the 1971 act gave no credit for previous expansion in determining eligibility for capitation grants, every eligible medical school has met the expansion requirements to participate in the capitation grant program [Ref. 4].

3. Estimated Behavioral Relationships

The stochastic form of structural equation (4) is:

$$\mathrm{CAP} = \beta_{51} + \beta_{52}\,\mathrm{CANTS3} + \beta_{53}\,\mathrm{MINFLI}_{t-1} + \beta_{54}\,\mathrm{MAJFLI}_{t-3} + \mu \quad (4)$$

where CAP is the capacity as previously defined, CANTS3 is the sum of the last three years' applicants, MINFLI_{t-1} is the minor federal obligations in millions of dollars lagged by one year, MAJFLI_{t-3} is the major federal obligation in millions of dollars lagged by three years and μ is the random disturbance term.

The particular lags selected are based on approximations of the response time to various incentives offered. While minor funding normally took the form of direct support loans or grants, major funding influenced both immediate increased enrollment and long-term construction of expanded physical plants, requiring a substantial lag to incorporate both facets of this effect.

The coefficients to be estimated are represented by the Greek letter β.[9] The disturbance term, μ, is a random variable and the following classical assumptions concerning the disturbance term and the data were made:

$$E(\mu) = \bar{0} \qquad (1)$$

$$E(\mu\mu^T) = \sigma^2 I \qquad (2)$$

X is a fixed matrix. (3)

X has a rank k.[10]

Prior to discussing this question in further detail the implications of assumption (2) regarding the disturbance term, μ, must be examined. In relation to time series data, it implies serial independence for the disturbance terms. That is covariance of μ_t and μ_{t+1} is equal to zero. When

---

[9] In the subscripts of the coefficients the first element refers to the number of the equation. The second element refers to the order in which the independent variables appear in a specific equation.

[10] X is the matrix of observed values of the independent variable. k is the number of independent variables.

dealing with a time series that is increasing this may not always be true. It is a distinct possibility that the disturbance terms (μ_t's) follow the first-order regressive scheme:

$$\mu_t = \rho\mu_{t-1} + \varepsilon_t$$

where $|\rho| < 1$ and ε_t satisfies the following assumptions for all t:

$$E(\varepsilon_t) = 0 \qquad (1)$$

$$E(\varepsilon_t, \varepsilon_{t+\rho}) = \sigma_\varepsilon^2 \qquad \rho = 0 \qquad (2)$$

$$E(\varepsilon_t, \varepsilon_{t+\rho}) = 0 \qquad \rho \neq 0 \qquad (3)$$

If this is the case, first-order positive autocorrelation is said to be present in the data and should be taken into account and generalized least squares rather than ordinary least squares used to estimate the coefficients. If this is not done the sampling variances of the regression coefficients would be seriously underestimated resulting in inefficient predictions by the model.[11] Underestimation of the variance of the coefficient will also result in larger t statistics and the possibility that an independent variable will be included in the regression that should not be [Ref. 6].

---

[11] Inefficient in this sense means the prediction of the model would have variances which would be larger than those resulting from using generalized least squares in estimating the coefficients.

Durbin and Watson developed a statistic, known as the Durbin-Watson "d" statistic, which is useful in testing for autocorrelation when the sample size is small [Ref. 7]. The d statistic is:

$$d = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2}$$

where e is the calculated residual, t the time period and n the number of observations. Unfortunately the sampling distribution of d depends on the observed values of the independent variables so it was only possible for Durbin and Watson to establish upper (d_u) and lower (d_l) limits for the significance levels of d.

In order to determine whether positive autocorrelation was present, the following hypotheses were tested:

$$H_o : E(\mu\mu^T) = \sigma^2 I$$

$$H_1 : \mathrm{Cov}(\mu_t, \mu_{t+1}) > 0 \quad t = 1, \ldots, n$$

The Durbin-Watson test statistic, d, was used. If d was greater than the upper limit, d_u, for the given significance level, H_o could not be rejected at that level. If d was less than the lower limit, d_l, H_o could be rejected but if d falls between d_l and d_u the test is inconclusive.

Ordinary least squares was first used to estimate the coefficients in equation (5). The Durbin-Watson statistic,

d, was less than d_1 (see Appendix C) indicating that first-order positive autocorrelation was present in the data. Generalized least squares was then used to re-estimate β_{51}, β_{52}, β_{53}, and β_{54}.

The Cochrane-Orcutt iterative technique was used to estimate the first-order serial coefficient, ρ, of the disturbances. This technique uses ordinary least squares to form an initial value for rho. The following iteration then takes place:

(1) All data are transformed by rho (e.g., $X_t - \hat{\rho}X_{t-1}$).

(2) Regression is performed on the transformed data.

(3) The regression coefficients are multiplied into the original dependent variables to recalculate the serially correlated areas.

(4) A new estimate of rho is formed.

(5) When rho changes by less than .005 from one iteration to the next, the process stops and regression output is produced [Ref. 8].

Data transformed in this manner adheres to assumption (2) and ordinary least squares may be used.

The resultant form of equation (5) was:

$$CAP_t=4328.07+0.085CANTS3+27.99MINFLI_{t-1}+8.64MAJFLI_{t-3}$$ [12]

$$\begin{array}{llllr} (693.95) & (0.013) & (19.19) & (2.86) & \bar{R}^2=.9856 \\ [6.23] & [6.31] & [1.45] & [3.01] & \end{array}$$

The Durbin-Watson test for this equation did not reject H_o.[13]

Students' t-test (see Appendix B) indicated that this coefficient of $MINFLI_{t-1}$ was not significant above the ninety per cent level while the remaining coefficients were significant at the ninety-nine per cent level.

The elasticity of the dependent variable with respect to the individual independent variable was calculated at the mean of both variables and the most recent observation (academic year 1972-73).[14] In the case of applicants $E_{\overline{CAP}, \overline{CANTS3}} = .50$ while $E_{CAP_{72}, CANTS3_{72}} = .56$. The elasticity of capacity with respect to $MAJFLI_{t-3}$ was calculated

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[12] The term in parentheses is the standard error of the estimated coefficient, while the term in brackets is the computed t-statistic of the coefficient. The term at the end of the equation is the adjusted coefficient of multiple correlation, $\bar{R}^2$. This format will be followed in all of the estimated equations.

[13] Appendix C tabulates the results of the Durbin-Watson tests for the estimated equations.

[14] If the relationship is linear, $y=a+\beta X$, the elasticity ε, is given by the formula: $\varepsilon_{y,x} = \beta\frac{X}{y}$. In the model the β is the point estimate of the coefficient, X is an observed value of the independent variable and y is the corresponding observed value of the dependent variable.

to be .04 at the mean values and .12 for academic year 1972-73. It would appear that while federal monies are having their impact, the primary motivation to expand is resulting from the press of applicants clamoring for admission into the select society of the licensed physician.[15]

A useful summary statistic which measures the proportion of the total variance of the dependent variable accounted for by the linear relation fitted is the coefficient of multiple correlation (R^2). This statistic, adjusted for degrees of freedom ($\bar{R}^2$), for equation (5) is .9856. Almost the entire sample variance of the dependent variable, CAP_t, was "explained" by the hypothesized linear fit.

B. FACTORS AFFECTING THE NUMBER OF APPLICANTS TO MEDICAL SCHOOL

Because the number of applicants in previous years has an effect on the capacity of medical schools, it should prove useful to examine just what factors determine the number of applicants in any given year. Certainly the reasons a college student applies to medical school are numerous and complex (e.g., prestige, humanitarianism, income, aptitudes, family tradition, etc.). However, all

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[15] The elasticity of MINFLI was calculated at the mean of both variables and in 1964, the final year with observed values for this variable. The results were .0067 and .0073, indicating that minor spending by the federal government has little if any effect on the capacity of medical schools. The results of the t-tests which require a lower level of significance for this variable to be included in the model confirm this hypothesis.

of these factors cannot be examined here, and it is proposed that the income of a physician and the scholarship and loan funds available to the student to finance a medical education affect a sizeable portion of the students. These factors can be evaluated with the same regression techniques used in the previous equation.

1. Income[16]

A great deal of difficulty was experienced in obtaining consistent income data for physicians in the United States. Due to the lack of Internal Revenue Service data and any consistent data from other government sources, the authors were forced to use median income data as published by Medical Economics in its new annual survey.[17] Unfortunately this survey only became annual in 1962. Prior to that it was published every three or four years. In order to avoid the potential problem of missing observations in the income time series, a linear growth rate was assumed. The missing observations were replaced with the interpolated figures.

In recent years there has been a trend away from self-employment toward incorporation by physicians on the

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[16] See Appendix H for a more detailed discussion of problems involved in the selection of a valid indicator for income.

[17] As reported to the authors during a telephone conversation with IRS statistician Jack Blackssin (202-964-6111) on 14 January 1975 the only income data available was aggregate billions reported by doctors' offices. This data has only been kept since 1958 which includes a gap in 1961 when the accounting procedures were changed.

higher end of the income scale. Presumably the primary motivation for this is to escape some income taxes and to benefit from the more liberal corporate pension plan laws. The constructed indicator of income attempted to compensate for this phenomenon.

The final variable for income consists of net median earnings for all self-employed physicians up to 1969.[18,19] From 1969 to 1973 net median earnings were used for only those self-employed physicians practicing in partnership. Since partnerships tended to earn more than solo practitioners or the median for all physicians, it was hoped that this would compensate for the shift of those physicians with higher incomes to incorporation.[20]

2. Federal Scholarships and Loans

All of the federal legislation discussed in the section on medical school capacity included substantial contributions to the loan and scholarship funds of the various schools. While the available loans and scholarships

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[18] In constructing the income variable the lower salaries a physician can expect to earn while serving as an intern or resident were not considered. Also not considered were the lower expected salaries an immigrant might face if he were not licensed. These factors were excluded because the model includes only those FMG's who become licensed.

[19] Net in this case is defined as income from practice minus top-deductible professional expenses but before income taxes.

[20] Due to the lack of median income data for those physicians who are incorporated, it was not possible to construct a weighted average net median income for the years from 1969 to 1973.

TABLE II

SELF-EMPLOYED VS. INCORPORATED PHYSICIANS, 1969-1973

	Self-employed Physicians	Incorporated Physicians
1969	95%	5%
1970	91%	9%
1971	83%	17%
1972	70%	30%
1973	68%	32%

Source: Reference 9

are not derived exclusively from federal funds, the major increases and adjustments in this area have been brought about by federal policy and the contribution of the government will be used as a measure of the trends in this area.

The Health Professions Education Act of 1963, as amended in 1965, authorized the government to provide 90% of the funds for student loans, with the remainder to be provided by the school. A ceiling of $2,000 per student per year was intially established, with repayments over a ten-year period beginning three years after graduation, at an interest rate of 3%. The amendment increased the maximum to $2,500 per year for both loans and scholarships, and established a program of loan forgiveness, with up to 50% of the laon forgiven at the rate of 10% per year for a physician practicing in an area listed by the government as being short of physicians. Total forgiveness of the loan was authorized if the physician established practice in a low-income rural area.

The Health Manpower Act of 1968 did little to change this program, but the Comprehensive Health Manpower Training Act of 1971 raised the ceiling on scholarships and loans to $3,500, with loan forgiveness of 85% for a physician practicing in an area of medical manpower shortage for three years [Ref. 4].

The extent to which this program has grown is somewhat evidenced by these statistics: In 1972-73, 23,561 of the 47,546 students enrolled in medical school (49.5%)

applied for financial aid, and 22.770 (48.8% of enrolled students) received it. The average loan or grant was $2,171 [Ref. 3].

3. Estimated Behavioral Relationships

Equation (4) of the model examines the effects of nominal income and the federal student loans and scholarships. The stochastic form of this equation is

$$\text{APPLICANTS}_t = \beta_{41} + \beta_{42}\,(\text{INCOME})^2 + \beta_{43}\,(\text{FSL})^{21,22} \qquad (4)$$

where FSL represents the amount of federal funds available for loans and scholarships (in millions of dollars), and INCOME is net median income in thousands of dollars. The estimated form of equation (4) is:

$$\begin{array}{llll} \text{APPLICANTS}_t = & 7802.93 & + 13.25\,(\text{INCOME}_t)^2 & - 243.42\ \text{FSL}_t \quad \bar{R}^2=.9739 \\ & (1925.7) & (1.45) & (97.14) \\ & [4.05] & [7.10] & [2.50] \end{array}$$

The sign of the coefficient of FSL is indeed puzzling. It indicates that an income in scholarship and loan funds made by the federal government will result in fewer applicants. The elasticity calculated for 1972-73 is -0.17 indicating an increase of ten per cent in federal funds would have resulted in a 1.7% decrease in the number of applicants.

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[21] Note should be taken that this relationship is not linear, as the variable INCOME is squared.

[22] For ease of computation the variable INCOME was given in thousands of dollars.

Although the principle of maximum correlation tends to select this formulation as the correct specification, the test conducted using the t statistic would reject the hypothesis, at the ninety-five per cent level, that this coefficient is different from zero. Since there appeared to be no obvious explanation for the apparent negative effect of federal monies, equation (4) was also specified without variable FSL. The respecified equation is:

$$\underset{\substack{\\ \\ \\ \\}}{\text{APPLICANTS}_t} = \underset{\substack{(2760.10) \\ [2.67]}}{7384.99} + \underset{\substack{(1.25) \\ [8.72]}}{10.95}\,(\text{INCOME}_t)^2 \quad \bar{R}^2 = .9660 \qquad \text{(4a)}$$

The $\bar{R}^2$ for this equation is less (.0079) than for the initial specification but either accounts for almost the entire sample variance of the dependent variable.[23]

The Durbin-Watson statistic, d, falls in the region where the test is inconclusive for both equations (4) and (4a). After using generalized least squares, d still

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[23] The equation was re-estimated using data from the years 1965-1973 which omitted those years for which the value of FSL was zero. The resultant equation was:

$$\text{APPLICANTS}_t = \underset{\substack{(4272.81) \\ [-2.03]}}{-8710.14} + \underset{\substack{(0.20) \\ [5.10]}}{1.05}\,(\text{INCOME}_t)^2 \; \underset{\substack{(266.27) \\ [1.70]}}{-453.04\,\text{FSL}_t} \quad \bar{R}^2=.9198$$

This equation is consistent with previous findings, and thus far there is no plausible reason for the negative coefficient of FSL_t.

remained in the inconclusive range. The estimated forms of both (4) and (4a) were arrived at using generalized least squares. The elasticity of applicants with respect to income calculated to 1.07 at the mean and 1.58 for the 1972-73 observations.

C. THE PRODUCTION OF A DOMESTIC PHYSICIAN

Producing a licensed physician from a student enrolling in medical school is a complex process. Not only must a student successfully complete his medical school education, but he must also satisfy the additional requirements of internship/residency. Finally, he must take and pass a licensure examination before he is allowed to provide any unsupervised patient care.

1. Medical School Attrition

It is somewhat surprising that a constant representing the percentage of entering students that become physicians is not readily available. Every year the Journal of the American Medical Association publishes precise figures on entering students and graduating students, on applicants and acceptance rates, carefully sorting out multiple applications in collecting the data. Statistics on medical licensure carefully distinguish between licensees that represent accessions to the profession as opposed to cross-licensure between various states. Yet the section on student attrition in the annual report on Medical Education in the United States is always prefaced by disclaimers attempting to explain why these numbers are suspect.

Originally, attrition was defined in this report as the number of entering students that failed to graduate four years later. This ignored the possibility that a student who did not graduate in four years might graduate in five or six, having dropped out a year or two for reasons which might be financial, personal, or academic. On the other hand, a vacancy created by a student leaving school was frequently filled by a student transferring in from abroad, through programs such as COTRANS (see Appendix D) [Ref. 10].

Yet the attrition figure computed seemed to be a reasonably good estimator, not only because the two inaccuracies tended to offset each other, but also because it did in fact present a true picture of how many graduates could be expected four years later, given a certain student input, and assuming the continued availability of foreign trained American students to fill the vacated spaces in total enrollment. The number of enrolled first-year students who eventually graduated would be of little value, since it would convert the availability of the finished product into a variable with its own probability distribution, complicating any model. But this statistic became useless as the three-year medical school graduate came into being.

Prior to 1965, only five medical schools offered the opportunity for a small number of highly qualified and carefully selected students to complete their education at an accelerated pace. This was sometimes accomplished

through merely eliminating vacations from the schedule, but often involved waiving required courses, or combining medical school with the pre-med training in a six-year program [Ref. 11]. But every major piece of federal legislation offering financial assistance to medical schools, beginning with the HPEA in 1963, included provisions for special priorities or increased funding for schools that shortened the period of education. When the AMA examined these shortened programs in 1972, 46 of the 106 degree-granting schools made provision for early graduation [Ref. 3]. In excess of 10% of the students were permitted to graduate in 36 months or less in 26 schools, 12 of which had better than 90% of their students in this type of program.[24] To show the impact of three-year programs, if one attempts to apply the earlier definition of attrition in the later period, he soon discovers that, of the 10,401 students entering medical school in 1969, 10,424 of them graduated in 1973, producing a negative attrition of 23 students! But applying that technique to the students entering in 1950 through 1965 and graduating in 1954 through 1969 gives a constant of .8953, indicating that 10% is a reasonable estimator of the attrition rate during that period.

In recent years, JAMA has tabled attrition by the change in total enrollment, determining how many of the

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[24] One year earlier, before the CHMTA of 1971 went into effect, only six schools were in the 90% category.

students beginning a school year neither graduated nor enrolled in the succeeding school term, and separating the attrition rates into year 1, year 2-3, and year 4 in an attempt to accommodate the three-year programs (see References 3, 11, 12, and 13). Yet even this number was modified to indicate that a large number of these students were not dropping out _per se_, but rather "pursuing advanced study." As a consequence, the values represented in Table III as adjusted attrition represent the minimum reportable level of attrition, while the unadjusted numbers would reflect an upper bound.

Dealing with so few observations, it is only possible to guess at what attrition should be. A student entering a four-year medical program in 1969 would face attrition rates of 2.84, 0.62, 1.28, and 0.24 per cent during four years of school, resulting in a total attrition rate of 4.98%. As an estimator, this could be biased downward, because it is taken from the adjusted figures, or upward, because a large percentage of students entering in 1969 completed their education in less than four years. In any case, given the greater selectivity afforded the medical school selection boards by the greatly increased number of applicants, it is not unreasonable to assume that attrition has fallen substantially in recent years, and that a constant of .95 at least provides a probable survival rate for medical students during this time. Because the great majority of students are in four-year programs,

TABLE III

MEDICAL SCHOOL ATTRITION, 1969-1973

	Year	Enrollment	Attrition	Adjusted Attrition	Adjusted Percentage
1969-70	1	10,401	304	295	2.84
	2/3	18,901	365	79	.42
	4	8,367	47	16	.19
		37,669	716	390	1.03
1970-71	1	11,348	293	287	2.53
	2/3	20,110	403	125	.62
	4	9,029	55	9	.10
		40,487	751	421	1.04
1971-72	1	12,361	298	270	2.18
	2/3	21,677	459	278	1.28
	4	9,612	61	36	.37
		43,650	818	584	1.34
1972-73	1	13,726	307	294	2.14
	2/3	23,381	365	251	1.07
	4	10,439	46	25	.24
		47.546	718	570	1.20

Source: References 3, 11, 12, 13.

equation (6) becomes

$$GS_t = (.95)\ CAP_{t-4} \qquad (6)$$

during the period 1970 to 1973.

2. Internship, Residency, and Licensure

The requirements imposed by the various states (the licensing authority) upon a domestic medical school graduate before he is licensed are not as varied as might be expected. In almost any state, the requirement is to complete a minimum of one year of internship and successfully pass a licensure examination. Any physician desiring to enter a medical specialty would undertake a subsequent period of resident training, but completion of a residency in no way affects eligibility for licensure.

In 1968, the AMA established a goal of combining internship and residency into one consolidated period of training, a policy which is to be in effect for all AMA-approved residencies by 1 July 1975 [Ref. 12]. Part of the implementation included a policy that the first year of residency would be considered equivalent to the internship for all intents and purposes, including licensure. Thus one year of subsequent training is the minimum time to licensure.

The examination requirement is a passing grade of 75 on each of the three parts of the Federal Licensure Examination (FLEX). The student need not complete the entire period of training before taking the exam, and need

not take the three parts all at one time or even in sequence. Part I involves the basic medical sciences, and may be taken as early as the second year of medical school. Part II is more specialized, and may be taken during the fourth year of medical school. Part III is an oral examination and may be taken only when the first two have been satisfactorily completed [Ref. 14]. Thus it is quite possible for a student in his final year of medical school to have passed all the examination requirements and still not be licensed for another 18 months, while other students in the same class might complete a five-year residency before even attempting the exam. Table IV gives the failure rates for each part of the examination since 1950.

The number of individuals who graduate from medical school but fail to meet these additional requirements for licensure appears to be minimal. While many studies of attrition in medical school have been reported, no studies of attrition during residency/internship could be located, nor are there any intimations of a domestic unlicensed physician underground, as there was in the foreign graduate sector. While the failure rates in Part I are by no means insignificant, it should be noted that several schools require all students to take Part I while attending school, and there is no penalty for failure to any student taking the exam. In reporting the results of testing, the Journal of the American Medical Association does not break down the statistics between individuals taking the exam for the first

TABLE IV

FAILURE RATES FOR FEDERAL LICENSURE EXAMINATION, 1950-1973

	Part I	Part II	Part III
1950	12.3	1.4	0.9
1951	13.3	1.4	1.7
1952	13.2	0.8	4.3
1953	13.1	2.5	2.9
1954	11.2	2.8	3.8
1955	14.2	1.6	0.6
1956	9.8	1.2	0.6
1957	8.9	0.8	0.6
1958	12.1	2.5	0.6
1959	11.7	2.6	0.4
1960	13.2	2.7	0.3
1961	14.0	1.8	1.4
1962	15.1	3.4	2.0
1963	14.4	2.2	1.9
1964	12.5	1.8	1.9
1965	17.4	1.6	1.5
1966	11.8	2.1	1.9
1967	12.2	2.0	1.5
1968	13.0	2.0	2.0
1969	12.8	1.9	2.1
1970	14.6	1.8	2.3
1971	14.1	2.0	2.0
1972	17.0	2.7	2.2
1973	16.8	2.7	2.0

Source: Reference 14.

time and individuals with previous failures (as it does in reporting the ECFMG results), apparently considering the distinction to be inconsequential.

The primary difficulty in defining the transition from student to licensed physician appears to be in identifying the time period involved. Included in the licensure statistics for each year are medical school graduates of several previous years, and no break-down of the licensees is attempted. Consequently the average interval from graduation to licensure is unobtainable.

The general character of the licensure problem is thus quite similar to that of student attrition previously discussed. In that example, given an input in a particular year, a certain percentage of that number would graduate four years later, the value of the model by no means diminished if these graduating students were not all members of the same entering class four years previous. Here the same technique was applied, using the ratio of new licensees to the number of students graduating one year prior, that being the minimum time to licensure.

Using 21 observations from 1952 through 1972, the average value of the constant n was .9595, with a standard deviation of .0401. The final form of equation (7) is then:

$$\mathrm{DMGL}_t = .9595\ \mathrm{GS}_{t-1} \tag{7}$$

IV. THE FOREIGN PHYSICIAN

The role of the foreign trained physician is of increasing importance in the medical care system (see Table V). In 1950 the number of physicians trained abroad who were newly licensed to practice medicine in the United States was 300. By 1970, 3,016 initial licenses were granted to foreign trained physicians while in 1973, 7,419, or 44.5% of initial licenses, were issued to foreign trained physicians. Viewed from another perspective, the supply of doctors in the United States, as measured by the ratio of M.D.'s to the population, has increased from 145 per 100,000 in 1950 to 164 per 100,000 in 1970. But without the immigration of foreign medical graduates this ratio would have been virtually the same in 1970 as it was in 1950.[25]

In the context of a traditional economic model the foreign physician represents the short-run response to an increase in demand for physicians.[26] Since it takes a minimum of four years for an increase in the capacity of

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[25] All of the above data are contained in Reference 15.

[26] Foreign physicians are defined to include only those of foreign origin who attended medical school abroad. Thus American graduates of foreign medical schools and foreigners who graduate from American medical schools are not considered in this category. In either case the numbers concerned are relatively small (see Appendix D, Table XIII).

TABLE V

PERCENTAGE OF ACCESSIONS TO THE MEDICAL PROFESSION THAT ARE GRADUATES OF FOREIGN MEDICAL SCHOOLS, 1950-1973

1950	5.1
1951	7.2
1952	8.3
1953	9.4
1954	9.8
1955	11.7
1956	11.4
1957	13.6
1958	14.9
1959	19.7
1960	17.7
1961	19.7
1962	17.0
1963	17.5
1964	16.5
1965	16.7
1966	18.5
1967	22.1
1968	22.4
1969	23.1
1970	27.3
1971	35.2
1972	46.0
1973	44.5

Source: References 14, 16, 17 and 18.

medical schools to produce practicing physicians, any increase in demand will have to be met in the short run by foreign trained physicians.

In 1957 the Education Council for Foreign Medical Graduates (ECFMG) came into being. It was created by the American Hospital Association, American Medical Association, Association of American Medical Colleges, and the Federation of State Medical Boards of the United States for the purpose of dealing with mutual problems relating to foreign residents and interns. By July of 1961, a certifying examination was required of all foreign graduates seeking residency or internship in the United States. The stated purpose of the examination was to test a candidate's ability to understand spoken English as well as his professional knowledge. It was hoped that this screening process would alleviate some of the existing problems with foreign residents. The ECFMG examination is currently administered twice a year in sixty centers located both inside and outside the continental United States. After successful completion of the examination, the foreign medical school graduate is eligible for acceptance into a training program in the United States. The issuing of a license to practice medicine rests with the individual states, each of which has its own requirements.

Thus the number of foreign trained doctors can be broken into two separate parts. First those physicians who have permanent residency status and have been licensed

to practice medicine in the United States and secondly those who are in training as interns, residents, and clinical fellows. It is this first group with which the model attempts to deal.

The second group was excluded from the model because of the absence of specific data relating to its membership. In 1963 the Institute of International Education attempted to identify those foreign interns and residents who were visitors as distinguished from those who were immigrants [Ref. 19]. It was concluded that reliable data concerning the number of actual immigrants in this group was just not available because some individuals with Immigrant Visas were visitors while some with Visitor Visas were potential immigrants. For example, in 1963 twenty-five per cent of those foreigners classified as visitors held Permanent Resident or Visitors Visas while sixty-seven per cent held Student Visas. Unfortunately similar data for other years does not seem to exist. This instance does point out the existence of foreign physicians in the United States who are long-term or permanent residents who have never attempted to obtain citizenship and thus are ineligible to become licensed in the eleven states which require either United States citizenship or immigrant visas. In 28 other states a posted Declaration of Intent to become a citizen is a prerequisite which could also exclude this group from licensure [Ref. 20].

Although excluded from the model, the contribution of this second group to the delivery of health care must be recognized. At the very least, they provide services during their period of internship and residency prior to returning to their native lands. In addition, there are a large number of foreign physicians in this country who are receiving research training in forms other than internship and residency. Much of this training is strictly academic in nature, but some trainees are enrolled in non-accredited programs which are actually residencies not labeled as such because of a licensure requirement which the foreign graduates do not meet.

Prior to 1965, the immigration laws of the United States which set national quotas for countries outside the Western Hemisphere could have imposed restrictions on the incoming flow of foreign physicians.[27] In 1962, these quotas were relaxed in the case of persons possessing special education or skills who had made prior application for Permanent Resident visas. The 1965 amendment repealed the national quotas and replaced them with preference categories. Members of the professions and persons of exceptional ability in the arts or sciences are in the third category, following unmarried children of citizens and

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[27] This presupposes that there existed more physicians in these countries who wanted to immigrate than the quota allowed.

spouses and children of admitted aliens. Although to practice medicine in the United States the ECFMG examination must be passed by the FMG, the Department of Labor has placed foreign physicians who have practiced two years in their native land in this third category independent of their ECFMG examination status [Ref. 21].

With the passage of PL 91-225, which amended the Immigration and Nationality Act in 1970, the requirement for foreign medical graduates to leave the country upon completion of their training is discretionary with the Secretary of State. Those who emigrated from a nation which the Secretary has determined to require their skills or whose training program has been financed by their government must return to their country of origin for a minimum two-year waiting period. At the end of this time, they are eligible to re-apply for entry into the United States. Those physicians not in this category do not have to leave the United States upon completion of their training. Thus there is no constraint whatsoever upon foreign doctors entering and remaining from a large number of countries.

A. DEVELOPMENT OF THE VARIABLES

As previously stated, the flow of foreign physicians to the United States has reached significant proportions in recent years. The question addressed by the model is what factors affect the decision of a foreign medical graduate to emigrate to the United States. Luft suggests

that the principal decision factors can be grouped into four major categories [Ref. 21]. These are income, the quality of professional practice, the conditions of practice, and the cost of migration. Although Luft suggests methods of quantifying quality of practice and conditions of practice such as developing measures of the availability of support personnel (nurses, paramedics and secretaries) and the ease of locating in urban areas, this is an extremely difficult task when dealing with aggregate numbers over time. This made it necessary to develop surrogates for the factors affecting physician migration.

1. The Pool of Physicians Desiring to Practice in the United States

Physicians from overseas come to this country for a wide variety of reasons. There exists at any point in time a pool of physicians from abroad who have not been licensed to practice in this country but who are actively seeking licensure. Rather than attempting to identify and directly model the changing pattern of physician immigration to this country and developing a quantitative measure of those factors the following simplifying assumptions were made:

(1) The heterogeneity of non-economic reasons and changing patterns of immigration of foreign physicians can be ignored.

(2) This pool of foreign physicians seeking licensure can be modeled as a function of variables which will be designated INCOME and PASS.

Since it is required by most state licensing authorities that foreign medical graduates (FMG's) pass the ECFMG examination before applying for internship or residency programs or for licensure, pool is defined as the number of foreign physicians in any given year actively seeking licensure by applying for the ECFMG examination. This, of course, restricts the examination to the period since 1958, which was the first year the ECFMG examination was administered.

The ECFMG examination, which is given twice a year, may be taken as many times as the individual desires. However, the fee for the examination is increased from fifteen dollars for the initial exam to forty-five dollars for subsequent examinations with a final fifty dollars due upon arrival in the United States or Canada. Our pool can therefore be dichotomized into that portion taking the examination for the first time and that portion who are repeaters having failed to pass the examination on their first attempt.[28]

In order to enter the pool one needs only fifteen dollars and to remain only forty-five dollars is needed. One departs the pool when the examination is passed or he gives up. Due to the high percentage of repeaters taking the ECFMG examination and the low passing rate, it appears to be the exception rather than the rule for an individual

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[28] For a closer look at the dichotomy of pool, see Appendix E.

to pass the examination on the first attempt. The mean number of examinations failed by one group prior to taking the July 1972 exam was 4.4 with a range from one to seventeen [Ref. 22]. It is highly probable that the majority of these applicants had spent a minimum of two years in the ECFMG "pool" prior to the July 1972 examination.

2. The Rate of Successful Completion of the Education Council for Foreign Medical Graduates Examination

The variable PASS is defined as the percentage of those who take the ECFMG examination and successfully complete it in any given year. The purpose of this variable is to serve as an indication of prospective success to individuals when entering the pool and when exiting it after having passed the examination. It must be noted, however, that this variable also bears a mechanical relationship to pool in that the higher the pass rate in year t, the greater the number of applicants who will exit the pool, thus, *ceteris paribus*, leaving fewer to return the next year.

3. A Potential Income Indicator

There are several possible measures of income that could be used. It is reasonable to assume that the prospective immigrant is concerned not only with the nominal income he can expect to earn in the United States but also with the relative change in standard of living he can expect if he successfully makes the transition to practicing medicine in the United States. At this point the difficulties in

constructing an aggregate model over time must be taken into account and simplifying assumptions made. Without knowing the precise distribution of the origin of foreign physicians and how the actual or potential earning power of the physicians in their native lands translated into a standard of living relative to what they could expect in the United States, a valid income indicator was difficult to construct.[29]

The variable INCOME in this equation was the net median earnings in dollars of self-employed physicians practicing in the United States.[30,31]

B. SPECIFICATION AND ESTIMATION OF HYPOTHESIZED BEHAVIORAL RELATIONSHIPS

The model specifies two equations to explain the number of FMG's who were licensed in year t. The general structural form of these equations is given by equations (2) and (3) in the model section. The special stochastic forms of these equations used in this analysis are:

$$\mathrm{POOL}_t = \beta_{21}+\beta_{22}\mathrm{INCOME}_{t-3}+\beta_{23}\mathrm{PASS}_{t-2}+\mu \qquad (2)$$

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[29] See Appendix H for a more detailed discussion of problems involved in the selection of a valid indicator for income.

[30] While income was used in thousands of dollars in equations (5) and (5a), dollars was the unit used in equation (2).

[31] Refer to the discussion on income in Chapter III for the precise development of the figures used (pp. 30-31).

$$FMGL_t = \beta_{31}+\beta_{32}POOL_{t-2}+\mu \qquad (3)$$

$FMGL_t$ is the number of foreign medical graduates licensed in year t. INCOME, PASS and POOL are defined as previously discussed but now the exact lag structure is specified.[32]

With data gathered from the years 1958 to 1973, ordinary least squares was used to initially estimate the coefficients.

1. Physicians Desiring Licensure

Ordinary least squares resulted in the following estimation of equation (2):

$$\begin{array}{llll} POOL_t = & 5914.46+0.908INCOME_{t-3} & -257.81PASS_{t-2} & \\ & (4969.55)\,(0.063) & (105.33) & \bar{R}^2=.9648 \\ & [1.19] \quad [14.38] & [2.44] & \end{array}$$

The Durbin-Watson test did not indicate the presence of first-order autocorrelation in the data. Thus it was not necessary to re-estimate this equation using GLS.

Students' t-test indicates that the coefficients of both independent variables are significant at the ninety-nine per cent level (see Appendix B). If the estimated coefficient of income were the true value (the point estimate was in fact the actual value) equation (2) would indicate that a rise of $1,000 (nominal) dollars in net median income three years ago would result in an additional

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[32] Various models with different lag structures were examined. The estimated equations with the highest adjusted coefficient of multiple correlation were chosen to represent its specified relationship in the final model. See Appendix G.

953 FMG's joining the pool this year. The lag of three years can be interpreted as the time it takes income information to reach the FMG. Although this appears to be a rather lengthy interval, it is not unreasonable. When researching the income data, it was found, for example, that Medical Economics took approximately 13 months from the end of the calendar year before publishing their data.

The lag period can also be explained as the result of the income to be earned in the United States affecting the decision of the FMG prior to his actual graduation from medical school. The major point is that potential income in the United States does have a highly significant effect on the number of foreign graduates who wish to become licensed in this country. This is, of course, what one would expect.

Interpreting the estimated coefficients as the actual coefficient and examining changes in the dependent variable due to changes in the independent variables fails to take into account differing units of measure. If the estimated coefficients are considered a point estimate, a better method of analyzing the changes in the dependent variable is to calculate the elasticities with respect to the individual independent variables at specific points. The income elasticities of pool calculated at the mean of both variables and the most recent observation (1973) were

1.18 and 1.29 respectively.[33] The elasticities are the percentage change in the dependent variable brought about by a one-percentage change in the independent variable. A ten per cent rise in net median income would result in an increase of 11.8 per cent FMG's joining the pool at that point in time corresponding to the mean of both variables but in 1970 the same ten per cent increase would result in 12.9 per cent new physicians in the pool in 1973. Similarly the elasticities of $POOL_t$ with respect to $PASS_{t-2}$ were calculated at the mean of both variables and in 1973. The corresponding results were -0.44 and -0.23.

The coefficient of PASS is rather puzzling. One would expect that it would have a positive sign indicating a behavioral rather than a mechanical effect. A positive coefficient could have been interpreted as a greater probability of success encouraging more FMG's to join the pool, ultimately resulting in more licensed foreign graduates in the United States. The negative sign is the result of the obvious fact that a higher pass rate two years ago leaves fewer people returning to the pool for the next two years.

The adjusted coefficient of multiple correlation for this equation was .9538. That is slightly more than ninety-five per cent of the sample variance of the dependent variable, $POOL_t$, was explained by the independent variables,

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[33] Appendix F tabulates the elasticity calculations for all the estimated equations.

$INCOME_{t-3}$ and $PASS_{t-2}$, as fitted by the least squares estimation procedures.

2. Foreign Medical Graduates Licensed

Ordinary least squares was first used to estimate the coefficients β_{31} and β_{32} in equation (3). The Durbin-Watson statistic, d, was less than d_ℓ indicating the presence of first-order positive autocorrelation in the data. GLS was then used to re-estimate the coefficients. The resultant form of equation (3) was:

$$\begin{array}{llll} FMGL_t = & -2805.17 & + \; 0.287 \; POOL_{t-2} & \bar{R}^2 = .8542 \\ & (1461.89) & (0.064) & \\ & [1.91] & [4.48] & \end{array}$$

The t-test for significance of the coefficients indicated that the coefficient of $POOL_{t-2}$ was significant at the ninety-nine per cent level while the intercept was only significant at the ninety-five per cent level.

The positive sign indicated the larger the pool two years ago, the greater the number of foreign medical graduates licensed this year. The elasticities of $FMGL_t$ with respect to $POOL_{t-2}$ calculated at the mean (of the independent variable) and 1973 values were 2.08 and 1.20, respectively. Regarding the coefficient as a point estimate, this indicates that a ten per cent increase in members in the pool in 1971 resulted in twelve per cent increase in FMG's being licensed in 1973.

The lag of two years was supported by McGuinness in his examination of one group of FMG's in 1972 when he

found the average applicant took the ECFMG exam four or more times [Ref. 22]. One would also expect a lag between POOL and FMGL because not all FMG's are licensed immediately after successfully passing the ECFMG exam. Many of them serve as interns and residents for varying lengths of time prior to becoming licensed.

The negative intercept is most likely the result of extrapolation beyond the range of the data.[34]

The adjusted coefficient of multiple correlation for this equation is .854 indicating that over eighty-five per cent of the sample variance of $FMGL_t$ is explained by $POOL_{t-2}$.

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[34] Dividing the intercept by the coefficient of $POOL_{t-2}$ would locate the point where the regression line crosses the $POOL_{t-2}$ axis. This could be interpreted as the minimum pool size before licensing occurs. This number is 9773 which makes it rather difficult to accept this interpretation.

V. THE MEDICAL SPECIALIST

A. THE VARIABLES

The necessity for insuring that an optimal mix of medical specialties is achieved at a time when medical manpower is in short supply has been discussed previously. A model that could accurately reflect the decision process of a medical school graduate in choosing a field in which to specialize after graduation would be of substantial value. The proposed model in its general form is:

$$EP^i_t = f_i \ (OC^i_{t-x_i}, \ JO^i_{t-x}) \ , \qquad (8)$$

recalling that EP^i_t is the number of physicians entering specialty i at time t, $OC^i_{t-x_i}$ represents the opportunity cost of selecting specialty i in lieu of another, and $JO^i_{t-x_i}$ represents the job opportunities within that field.

All of the variables included in that model are variables which had to be developed; none were ever specifically identified or tabled as such in the literature. Several approaches were taken in an attempt to produce valid representations of these factors, and each was frustrated by incomplete data, redefinitions of data during collection, and whole areas which had never been seriously examined.

1. Entering Physicians

While the number of physicians practicing in the United States has been reported annually for over fifty

years, the first attempt to break down the number of physicians by the medical specialty which constituted their primary activity was not made until 1962, when Congress first expressed interest in this information. The first report listed each recognized medical specialty, the total number of physicians in each field (including interns, residents and fellows), the number of interns currently on duty in the field, and the percentage of residencies filled in each specialty.

It would appear that the number of licensed physicians entering into each field could be estimated with some accuracy, given that the number of newly licensed physicians representing accessions to the profession is known. The number of licensed physicians at the end of year t should equal the licensed physicians from year t-1 plus the accessions to the profession in year t minus whatever attrition (death, retirement) occurred during the period. Of the above, only attrition is not readily available and could be easily calculated. This attrition can then be assessed against each specialty, on a weighted or uniform percentage basis, resulting in a representation of the holdovers in each specialty from year t-1. Subtracting the specialty strengths for t-1 adjusted for attrition from the specialty strengths for year t gives a representation of the specialty breakdown for the newly licensed physicians in year t.

An attempt to develop the variable EP_t^i in this manner produced several results which could not be reconciled.

During the three-year period from 31 December 1967 to 31 December 1970, the number of physicians in the field of general practice dropped from 68,920 to 57,948, an attrition of 10,972 during a period in which calculated attrition for the entire period was only 5,378! [Refs. 10, 11].

During the period 1968-1970, an effort was made to redefine medical specialties, and it might appear that a large number of general practitioners had simply been reclassified into another specialty [Ref. 23]. But the logical directions of this transfer--pediatrics, obstetrics/gynecology, or internal medicine--showed no comparable increase during this period. The answer must be the existence of an extensive pattern of lateral mobility between the various specialties.

One way to deal with this problem might be to approximate specialty selection by the year-end strength in each specialty, effectively allowing each physician to reselect his field of practice. With appropriate time lags to allow for preparation, opportunity cost and job opportunity should be significant influences in this model as well.

But the data is not sufficient to permit such an effort at this time. Only nine data points are available, and they are distorted by the redefinition of specialties in 1968-1970, and the combination of internships and residencies for reporting purposes in 1965 (resulting in an apparent net gain in licensed physicians of 10,581 at a

time when accessions totaled only 9,147) [Ref. 10]. Only when consistent data has been collected over an extended period of time would a serious attempt at modeling this process be rewarding.

2. Opportunity Cost

The opportunity cost of selecting a medical specialty with less income potential than another should be a significant factor in the selection process. But the development of an estimator of this cost involves more than just a comparison of median income. The period of additional training required is an important consideration, and must be included in the variable. A specialist in pediatric cardiology (a fairly new specialty) is quite high on the income scale. But the time interval from medical school graduation until beginning to earn this income is considerable, involving a four- to five-year residency in cardiology followed by a two- to three-year fellowship in pediatrics or pediatric cardiology. Throughout this period of training, the opportunity cost is considerable, since a resident's income is less than half the median income for any medical specialty. Only a weighted average of the opportunity costs over an extended period could accurately reflect the way in which this influences the decision. And this cannot be properly developed until accurate income figures for each specialty are known.

The difficulties in obtaining an overall median physician's income have already been discussed, with Medical

Economics as almost the sole source of information in this field. Information has been published frequently, if irregularly, on the median income of physicians in five major specialties (general practice, general surgery, internal medicine, pediatrics, and obstetrics/gynecology). This is subject to all of the previous qualifications with respect to the sample used to generate the data, but it is the only data available. Average salaries for intern/residents have been published annually by the Journal of the American Medical Association.

3. Job Opportunity

Perhaps the best figure to use in representing the need for physicians in a particular specialty would result from a comparison of the present specialist-to-population ratio with the specialist-to-population projected as optimal for the nation's health care. But a determination of how many specialists in internal medicine are needed per 100,000 population, for instance, has as yet not been calculated by either the federal government or the professional medical associations.

Attempts have been made in this direction, by several concerns, however. Mason examined the staffing of six large prepayment plans, calculating their specialist-to-membership ratios and presenting them as a basis for estimating national specialty needs [Ref. 24]. This generated much dissent from the groups. Kaiser Permanente of Portland claimed that (1) the ratios used reflected several compromises

with projected ideal ratios, and did not represent Kaiser's perception of need for specialists, (2) the ideal ratios were population-specific, tailored to the demographics of the Portland membership, and as such would be inapplicable to the nation as a whole, and consequently these figures would not be released [Ref. 25]. The U.S. Navy recently published a list of anticipated physician needs by specialty, but these were also calculated against a particular subset of the population, and would not be valid in other areas [Ref. 26].

Some of the individual specialties are examining this problem through their professional societies. The American Academy of Family Physicians, for instance, has projected a ratio of one family practitioner per 2,500 population as a minimum goal, to be re-evaluated as the specialty approaches it.

If one is willing to assume that the distribution of medical specialists is responsive to the needs of society, then the residencies offered in each specialty might be a valid indication of job opportunity, and the percentage of fill in each type of residency a reasonable representation of the students' response. But again there are distortions.

General practice, traditionally the primary care level of medicine, has reflected a decrease in numbers every year since 1964. In 1972, only 59% of the available residencies in general practice were filled, a total of 1,026 residents. But incorporated in the statistics on

general practice is the new medical specialty of family practice, created in 1968 to give proper recognition and prestige to primary care. Of these 1,026 general practice residents reported above, 919 were family practice types, filling 86% of all available first-year resident positions [Ref. 3]. This distortion will be present until such time as family practice has grown sufficiently to be listed as a separate specialty or until general practice is phased out completely, and makes identification of student response in this area somewhat difficult. Yet either the response of students to available residencies or the realignment of residencies among the various specialties may well prove to be a reasonable proxy for job opportunity.

VI. CONCLUSION

The model in its final form consists of the following equations:

$$A_t \equiv FMGL_t + DMGL_t \tag{1}$$

$$POOL_t = 5914.46+0.908\ INCOME_{t-3}-257.81\ PASS_{t-2} \tag{2}$$

(4969.55) (0.063) (105.33) $\bar{R}^2=.9538$

[1.19] [14.38] [2.44]

$$FMGL_t = -2805.17 + 0.287\ POOL_{t-2} \tag{3}$$

$\bar{R}^2=.8542$

(1461.89) (0.064)

[1.91] [4.48]

$$APPLICANTS_t=7802.93+13.25(INCOME_t)^2-243.42\ FSL_t \tag{4}$$

(1925.7) (1.45) (97.14) $\bar{R}^2=.9739$

[4.05] [9.10] [2.50]

$$CAP_t=4328.07+0.085CANTS3+27.99MINFLI_{t-1}+8.64MAJFLI_{t-3} \tag{5}$$

(693.95) (0.013) (19.19) (2.86) $\bar{R}^2=.9856$

[6.23] [6.31] [1.45] [3.01]

$$GS_t = 0.95\ CAP_{t-4} \tag{6}$$

$$DMGL_t = 0.96\ GS_{t-1} \tag{7}$$

It is of interest to note that there are two economic variables in this model which are to some extent under the control of the federal government, and represent potential

policy instruments to generate greater physician flow: MAJFLI, which is obvious and direct, and INCOME, which while not expressly determined by the government, can be substantially affected by federal policy (national health insurance proposals, for instance).

The length of time required to generate physician supply is also of interest. Suppose that the income of a physician, as defined in the model, increased 10% in 1974. This increase would generate a 15.8% increase in the number of applicants to medical school in 1974, resulting in pressure to expand domestic medical school capacity during the years 1975, 1976 and 1977. The resultant increase in the number of medical students would begin to produce additional licensed physicians after 1980.

The application of a 10% increase in direct federal funding of medical schools in 1974 would produce an increase of almost 2% in capacity by 1977, generating a corresponding increase in graduates in 1981 and in licensed physicians in succeeding years.

It should be noted that the federal government has alternative means of augmenting the flow of physicians, in that the creation of a federal medical school will directly increase the supply. Given that graduates of a federal medical school would be obligated for federal service upon graduation, whether or not expenditures in this direction might prove more efficient in increasing the supply of physicians should be addressed in future research.

A refined version of this model should investigate the application of a distributed lag structure in estimating the effect of variables involving the flow of foreign physicians to this country. This technique might afford future users a more accurate representation of this aspect of the model.

Finally, as discussed very early in this paper, the federal government has at least two major interests in increasing the flow of new physicians, and hence the stock of physicians. One is, of course, the concern with insuring the provision of an adequate number of physicians to support the population as a whole. The other more specific reason stems from the need to see that a sufficient number of doctors voluntarily choose to serve as military physicians. It is believed that the present model, expanded to include a specified and estimated "specialty choice" model, are necessary components of a model which will predict these numbers. This topic should be addressed in future research.

APPENDIX A: BACKGROUND DATA

TABLE VI

NET MEDIAN INCOME OF SELF-EMPLOYED PHYSICIANS UNDER THE AGE OF SIXTY-FIVE, 1950-1973

Year	Median Income	Median Income Adjusted by the Consumer Price Index
1950	$12,049	$16,712
1951	13,150	16,898
1952	13,866	17,443
1953	14,584	18,201
1954	15,300	19,003
1955	16,017	19,973
1956	17,538	21,554
1957	19,058	22,603
1958	20,579	23,769
1959	22,100	25,305
1960	22,866	25,770
1961	23,583	26,319
1962	24,300	26,828
1963	25,050	27,330
1964	28,380	30,537
1965	28,960	30,640
1966	32,170	33,103
1967	34,745	34,745
1968	37,175	35,688
1969	38,530	35,100
1970	39,300	33,798
1971	40,450	33,330
1972	37,980	30,308
1973	39,100	29,403

Source: Reference 27.

TABLE VII

NET MEDIAN INCOME OF PHYSICIANS PRACTICING IN PARTNERSHIPS UNDER THE AGE OF SIXTY-FIVE, 1969-1973

Year	Median Income	Median Income Adjusted by the Consumer Price Index
1969	$40,550	$36,941
1970	42,650	36,679
1971	45,700	37,657
1972	51,070	40,753
1973	52,700	39,631

Source: Reference 27.

TABLE VIII

ACCESSIONS TO THE MEDICAL PROFESSION, 1950-1973

Year	Domestically Trained	Foreign Trained	Total
1950	5,694	308	6,002
1951	5,823	450	6,273
1952	6,316	569	6,885
1953	6,591	685	7,276
1954	7,145	772	7,917
1955	6,830	907	7,737
1956	6,611	852	7,463
1957	6,441	1,014	7,455
1958	6,643	1,166	7,809
1959	6,643	1,626	8,269
1960	6,611	1,419	8,030
1961	6,443	1,580	8,023
1962	6,648	1,357	8,005
1963	6,832	1,451	8,283
1964	6,605	1,306	7,911
1965	7,619	1,528	9,147
1966	7,217	1,634	8,851
1967	7,343	2,081	9,424
1968	7,581	2,185	9,766
1969	7,671	2,307	9,978
1970	8,016	3,016	11,032
1971	7,943	4,314	12,257
1972	7,815	6,661	14,476
1973	9,270	7,419	16,689

Source: References 14, 16, 17, and 18.

TABLE IX

EDUCATION COUNCIL FOR FOREIGN

MEDICAL GRADUATES EXAMINATION, 1958-1973

Year	Total Applicants	First Time Applicants	Percentage Repeaters	Percentage Passing Exam
1958	1,142	1,094	4.2	49.9
1959	4,840	4,477	7.5	44.2
1960	14,768	11,301	23.5	39.1
1961	14,222	8,204	42.3	37.8
1962	14,535	8,906	38.7	41.7
1963	19,130	11,391	40.5	31.6
1964	18,511	9,378	49.3	36.8
1965	18,337	9,204	49.8	42.7
1966	18,988	10,765	43.3	41.3
1967	19,188	11,777	38.6	46.0
1968	19,548	11,975	38.7	39.8
1969	22,598	12,447	44.9	36.0
1970	29,950	16,651	44.5	39.8
1971	31,033	16,525	46.8	31.2
1972	32,072	1,556	51.5	40.0
1973	37,023	18,964	48.8	33.2

Source: References 14, 28 and 29.

TABLE X

APPLICATIONS AND ENROLLMENT FOR MEDICAL SCHOOL, 1949-1972

School Year	Applicants	Acceptances	First Year Enrollment
1949-50	24,434	9,150	7,042
1950-51	22,279	7,254	7,173
1951-52	19,920	7,663	7,436
1952-53	16,763	7,778	7,425
1953-54	14,678	7,756	7,449
1954-55	14,538	7,878	7,576
1955-56	14,937	7,969	7,686
1956-57	15,917	8,263	8,014
1957-58	15,791	8,302	8,030
1958-59	15,170	8,366	8,128
1959-60	14,952	8,512	8,173
1960-61	14,397	8,560	8,298
1961-62	14,381	8,682	8,483
1962-63	15,847	8,959	8,642
1963-64	17,668	9,063	8,772
1964-65	19,168	9,043	8,856
1965-66	18,703	9,012	8,759
1966-67	18,250	9,123	8,964
1967-68	18,724	9,702	9,479
1968-69	21,117	10,092	9,863
1969-70	24,465	10,514	10,401
1970-71	24,987	11,500	11,348
1971-72	29,172	12,335	12,361[35]
1972-73	36,135	13,757	13,726

Source: Reference 3.

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[35] This is not a misprint. It appears that in 1971 more people were enrolled than accepted.

TABLE XI

TOTAL MEDICAL SCHOOL CAPACITY, 1949-1972

School Year	Number of Medical Schools	Total Enrollment	Graduating Students
1949-50	79	25,103	5,553
1950-51	79	26,186	6,136
1951-52	79	27,076	6,080
1952-53	79	27,688	6,668
1953-54	80	28,227	6,861
1954-55	81	28,583	6,977
1955-56	82	28,639	6,845
1956-57	85	29,130	6,796
1957-58	85	29,473	6,861
1958-59	85	29,614	6,860
1959-60	85	30,084	7,081
1960-61	86	30,228	6,994
1961-62	87	31,078	7,168
1962-63	87	31,491	7,264
1963-64	87	32,001	7,336
1964-65	88	32,428	7,409
1965-66	88	32,835	7,574
1966-67	89	33,423	7,743
1967-68	94	34,538	7,943
1968-69	99	35,833	8,059
1969-70	101	37,669	8,367
1970-71	103	40,487	8,974
1971-72	108	43,650	9,551
1972-73	112	47,546	10,191

Source: References 3 and 23.

TABLE XII

FEDERAL OBLIGATIONS TO UNDERGRADUATE MEDICAL SCHOOLS IN MILLIONS OF DOLLARS, 1950-1973

Fiscal Year	Loans and Scholarships	Institutional Support	Construction	Total
1950	--	--	5.3	5.3
1951	--	--	5.8	5.8
1952	--	--	12.0	12.0
1953	--	--	3.3	3.3
1954	--	--	1.5	1.5
1955	--	--	1.2	1.2
1956	--	--	7.9	7.9
1957	--	--	2.6	2.6
1958	--	--	9.4	9.4
1959	--	--	1.8	1.8
1960	--	--	3.4	3.4
1961	--	--	6.6	6.6
1962	--	--	6.9	6.9
1963	--	--	5.7	5.7
1964	--	--	3.3	3.3
1965	6.6	--	55.7	62.3
1966	9.8	6.6	48.8	65.2
1967	16.0	18.8	75.3	110.1
1968	18.0	25.7	91.9	135.6
1969	19.5	40.9	93.4	153.8
1970	15.7	56.2	108.7	180.6
1971	20.3	77.0	97.5	194.8
1972	21.3	140.4	5.5	167.2
1973	26.3	137.0	28.2	191.5

Source: Reference 30.

APPENDIX B

TESTS FOR SIGNIFICANCE OF COEFFICIENTS IN ESTIMATED EQUATIONS

The null hypothesis, H_o, that the coefficient is significantly different from zero was tested against the alternative hypothesis, H_1, that the coefficient is equal to zero using the students' t-test. A one-sided t-test is used. Whether the null hypothesis is $\beta_{ij} > 0$ or $\beta_{ij} < 0$ depends on the sign of the estimated coefficient. The computed t statistic for each coefficient is compared to the tabled percentile of the t distribution for the given degrees of freedom. If the tabled value is less than the computed value, the null hypothesis cannot be rejected at the level of significance represented by the tabled percentile of the t distribution. α was chosen in order not to reject H_o, if possible, at the $1-\alpha$ significance level.

Coefficient	Computed t	df[36]	α	$t_{1-\alpha}$
β_{21}	1.19	11	.01	2.718
β_{22}	14.38	11	.01	2.718
β_{23}	2.44	11	.20	0.876
β_{2A1}	30.246	14	.01	2.624
β_{2B1}	11.209	14	.01	2.624
β_{2B2}	4.534	14	.01	2.624
β_{2B3}	2.627	14	.01	2.624
β_{31}	1.91	11	.01	2.718
β_{32}	4.48	11	.05	1.796
β_{41}	4.05	16	.01	2.583
β_{42}	9.10	16	.01	2.583
β_{43}	2.51	16	.05	1.746
β_{4A1}	2.67	17	.01	2.567
β_{4A2}	8.71	17	.01	2.567
β_{51}	6.24	12	.01	2.681
β_{52}	6.31	12	.01	2.681
β_{53}	1.45	12	.10	1.356
β_{54}	3.01	12	.01	2.681

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[36] Degrees of Freedom.

APPENDIX C

TABLED RESULTS OF DURBIN-WATSON TESTS

$H_o : E(UU^T) = \sigma^2 I$

$H_1 : COV(U_t, U_{t+1}) > 0 \quad t=1,\ldots,n$

RESULTS OF TEST:

(1) Do not reject H_o if $d > d_\mu$.

(2) Reject H_o if $d < d_\ell$.

(3) If $d_\ell < d < d_\mu$ the test is inconclusive.

n = number of observations

k = number of explanatory variables

1-α = significance level

OLS : Ordinary least squares was used to estimate the equation.

GLS : The equation was re-estimated using generalized least squares.

Equation	n	k	α	d_ℓ	d	d_μ	Results
2-OLS	13	2	.01	0.70	1.82	1.25	(1)
2A-OLS	15	1	.01	0.81	2.35	1.07	(1)
2B-OLS	15	3	.01	0.59	2.10	1.46	(1)
3-OLS	14	2	.01	0.70	0.40	1.25	(2)
3-GLS	13	2	.01	0.70	1.91	1.25	(1)
4-OLS	20	3	.01	0.77	0.54	1.41	(2)
4-GLS	19	3	.01	0.74	0.97	1.41	(3)
5-OLS	17	4	.01	0.57	0.76	1.63	(3)
5-GLS	16	4	.01	0.57	1.66	1.63	(1)

APPENDIX D

COTRANS

The Coordinated Transfer Application System (COTRANS) is a cooperative effort of the Association of American Medical Colleges and the National Board of Medical Examiners. Its function is to assist United States citizens studying medicine abroad who wish to transfer from the foreign medical school to advanced standing in a medical school in this country. Although COTRANS has only been operational since 1970, its existence has resulted in the successful transfer of United States citizens from foreign to United States medical schools. In 1973, fifty-two per cent of those passing the COTRANS examination were successfully placed in this country. This is important since it counteracts the increasing number of citizens initiating their medical studies abroad which which if pursued to completion and resulting licensure in the United States are not accounted for by our model.

TABLE XIII

INITIAL U.S. LICENSES ISSUED TO AMERICAN GRADUATES OF FOREIGN MEDICAL SCHOOLS, 1957-1972[37]

1957	212
1958	284
1959	366
1960	386
1961	468
1962	201
1963	395
1964	200
1965	411
1966	252
1967	279
1968	335
1969	179
1970	198
1971	210
1972	240

Source: Reference 3.

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[37] Does not include U.S. graduates of Canadian medical schools.

APPENDIX E

POOL

The pool of FMG's attempting to pass the ECFMG examination can be divided into two groups. The first group, which will be called FIRST, consists of those taking the exam for the first time. The remainder, which are labeled RESDUE, are repeaters who failed on their first attempt but remained in the pool.

Pool was split into its parts and each part was examined separately. The relationships looked at were:

$$\text{FIRST}_t = \beta_{2A1}\ \text{INCOME}_{t-1} + \mu \tag{2A}$$

$$\text{RESDUE}_t = \beta_{2B1} + \beta_{2B2}\ \text{INCOME}_{t-1} + \beta_{2B3}\ \text{PASS}_{t-1} + \mu \tag{2B}$$

As with pool, ordinary least squares was used and the resulting equations tested for autocorrelation. Both equations were found to be free of autocorrelation. The equations in estimated form are:

$$\begin{array}{llll} \text{FIRST}_t = & 0.369\ \text{INCOME}_{t-1} & (.8271) & (2A) \\ & (0.012) & & \\ & [30.246] & & \end{array}$$

$$\begin{array}{llllll} \text{RESDUE}_t = & 8763\ + & 0.401\ \text{INCOME}_{t-1}\ - & 314.29\ \text{PASS}_{t-1} & (.9342) & \\ & (3335.59) & (0.035) & (69.318) & & (2B) \\ & [2.62] & [11.21] & [4.53] & & \end{array}$$

The adjusted $\bar{R}^2$ for these equations is:

$$.827 \tag{2A}$$

$$.934 \tag{2B}$$

Income is a motivating factor to join the pool and increased potential income in the future is a primary factor in keeping initial failures from departing the pool.

The variable $PASS_{t-1}$ enters the residual equation as a mechanical rather than behavioral influence. That is, a lower pass rate produces more RESDUE. After the previous experience with pool this was to be expected.

APPENDIX F

SELECTED ELASTICITIES OF THE VARIABLES

The coefficient of elasticity, E, is defined to be percentage changes of the dependent variable divided by the percentage change of the independent variable.

If the relationship is linear, $Y = A + BX$, the elasticity is given by the formula

$$E_{Y,X} = B\frac{X}{Y} \quad .$$

If the relationship is quadratic, $Y = A + BX^2$, the elasticity is given by:

$$E_{Y,X} = 2B\frac{X^2}{Y}$$

These formulas were used as required to calculate the elasticities of the dependent variables with respect to each independent variable in the estimated equations of the model. The B is the estimated coefficient while the X and Y values were taken at the mean and most recent observations. The results follow.

Equation	Y	X	$E_{\bar{Y},\bar{X}}$	$E_{Y_{1973},X_{1973}}$
2	$POOL_t$	$INCOME_{t-3}$	1.18	1.29
2	$POOL_t$	$PASS_{t-2}$	-0.44	-0.23
2A	$FIRST_t$	$INCOME_{t-1}$	0.99	0.99
2B	$RESDUE_t$	$INCOME_{t-1}$	1.41	1.13
2B	$RESDUE_t$	$PASS_{t-1}$	-1.38	-0.70

Equation	Y	X	$E_{\bar{Y},\bar{X}}$	$E_{Y_{1973},X_{1973}}$
3	$FMGL_t$	$POOL_{t-2}$	2.08	1.20
4	$APPLICANTS_t$	$INCOME_t$	0.14	0.21
4	$APPLICANTS_t$	FSL_t	-0.10	-0.18
4A	$APPLICANTS_t$	$INCOME_t$	1.07	1.58
5	CAP_t	CANTS3	.50	.56
5	CAP_t	$MINFLI_{t-1}$[38]	.0073	.0067
5	CAP_t	$MAJFLI_{t-3}$	.04	.12

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[38] These observations correspond to the 1964 values which were the last entries for this pair of variables.

APPENDIX G

THE LAG STRUCTURE AND THE SPECIFICATION OF THE MODEL

When considering the initial specification of the model it was suspected that the effect of some of the independent variables would not be immediately felt. For this reason various lags on these variables were investigated. In choosing among alternative specifications of the set of independent variables the principle of maximum correlation was used. The equation with the highest adjusted coefficient of multiple correlation, $\bar{R}^2$, was chosen to be the correct specification [31].

Not all of the alternative specifications investigated will be tabulated in this appendix. Equations consisting of the unlagged variables and the correctly specified equations have been tabled in this appendix in order to illustrate the results of using the principle of maximum correlation.

EQUATION (2)

$$\begin{array}{lllll}
\mathrm{POOL}_t = & 5914.46 + & 0.908\ \mathrm{INCOME}_{t-3} & - 257.81\ \mathrm{PASS}_{t-2} & \bar{R}^2 = .9538 \\
 & (4969.55) & (0.063) & (105.33) & \\
 & [1.19] & [14.38] & [2.44] &
\end{array}$$

$$\begin{array}{llll}
\mathrm{POOL}_t = & 0.954\ \mathrm{INCOME}_{t-3} & - 141.402\ \mathrm{PASS}_{t-2} & \bar{R}^2 = .9521 \\
 & (0.051) & (39.822) & \\
 & [18.472] & [3.550] &
\end{array}$$

$$\begin{array}{lllll}
\mathrm{POOL}_t = & 10081.66 + & 0.679\ \mathrm{INCOME}_{t} & - 308.77\ \mathrm{PASS}_{t-2} & \bar{R}^2 = .9311 \\
 & (6037.01) & (0.081) & (127.07) & \\
 & [1.67] & [8.29] & [2.42] &
\end{array}$$

EQUATION (2A)

$$\begin{array}{lll}
\mathrm{FIRST}_t = & 0.369\ \mathrm{INCOME}_{t-1} & \bar{R}^2 = .8271 \\
 & (0.012) & \\
 & [30.246] &
\end{array}$$

$$\begin{array}{llll}
\mathrm{FIRST}_t = & 334.32 + & 0.359\ \mathrm{INCOME}_{t-1} & \bar{R}^2 = .8144 \\
 & (1514.69) & (0.045) & \\
 & [0.220] & [7.90] &
\end{array}$$

$$\begin{array}{lll}
\mathrm{FIRST}_t = & 0.338\ \mathrm{INCOME}_{t} & \bar{R}^2 = .7300 \\
 & (0.016) & \\
 & [20.709] &
\end{array}$$

EQUATION (2B)

$$\mathrm{RESDUE}_t = 8763.05 + 0.401\ \mathrm{INCOME}_{t-1} - 314.29\ \mathrm{PASS}_{t-1} \qquad \bar{R}^2 = .9344$$

(3335.59) (0.035) (69.318)

[2.62] [11.21] [4.53]

$$\mathrm{RESDUE}_t = 8309.70 + 0.367\ \mathrm{INCOME}_t - 295.27\ \mathrm{PASS}_{t-1} \qquad \bar{R}^2 = .9116$$

(3929.65) (0.038) (81.338)

[2.12] [9.49] [3.63]

$$\mathrm{RESDUE}_t = 1461.23 + 0.364\ \mathrm{INCOME}_{t-1} - 83.33\ \mathrm{PASS}_t \qquad \bar{R}^2 = .9195$$

(3813.95) (0.070) (67.55)

[0.383] [5.17] [1.23]

$$\mathrm{RESDUE}_t = 6136.39 + 0.387\ \mathrm{INCOME}_t - 266.97\ \mathrm{PASS}_t \qquad \bar{R}^2 = .8900$$

(4654.80) (0.045) (95.65)

[1.31] [8.49] [2.79]

EQUATION (3)

$$\mathrm{FMGL}_t = -2805.17 + 0.287\ \mathrm{POOL}_{t-2} \qquad \bar{R}^2 = .8539$$

(1461.89) (0.064)

[1.91] [4.48]

$$\mathrm{FMGL}_t = -1852.75 + 0.210\ \mathrm{POOL}_t \qquad \bar{R}^2 = .8268$$

(1341.16) (0.052)

[1.38] [4.04]

EQUATION (4)[39]

$$\text{APPLICANTS}_t = 7802.92 + 13.25\ (\text{INCOME}_t)^2 - 243.42\ \text{FSL}_t \qquad \bar{R}^2 = .9739$$

(1925.69) (1.45) (97.13)

[4.05] [9.10] [2.51]

$$\text{APPLICANTS} = 7237.67 + 15.18\ (\text{INCOME}_{t-1})^2 - 280.27\ \text{FSL}_{t-3} \qquad \bar{R}^2 = .9385$$

(1935.50) (171.87)

[3.74] [1.63]

EQUATION (4A)

$$\text{APPLICANTS}_t = 7384.99 + 10.95\ (\text{INCOME}_t)^2 \qquad \bar{R}^2 = .9660$$

(2760.10) (1.25)

[2.67] [8.71]

$$\text{APPLICANTS}_t = 9588.33 + 11.63\ (\text{INCOME}_{t-1})^2 \qquad \bar{R}^2 = .9278$$

(2063.49) (1.61)

[4.64] [7.19]

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[39] Income is in thousands of dollars

EQUATION (5)

$$CAP_t = 4328.07 + 0.085\ CANTS3 + 27.99\ MINFLI_{t-1} + 8.64\ MAJFLI_{t-3}$$

$$\bar{R}^2 = .9856$$

(693.95) (0.013) (19.19) (2.86)

[6.24] [6.31] [1.45] [3.01]

$$CAP_t = 4067.45 + 0.088\ CANTS3 + 38.68\ MINFLI_t + 8.46\ MAJFLT_{t-3}$$

$$\bar{R}^2 = .9745$$

(832.29) (0.016) (27.93) (3.159)

[4.88] [5.36] [1.38] [2.67]

$$CAP_t = 2237.45 + 0.121\ CANTS3 + 78.78\ MINFLI_{t-1} + 2.57\ MAJFLI_t$$

$$\bar{R}^2 = .9605$$

(591.08) (0.012) (34.68) (2.43)

[3.78] [9.39] [2.27] [1.05]

$$CAP_t = 2440.13 + 0.113\ CANTS3 + 95.53\ MINFLI_t + 4.87\ MAJFLI_t$$

$$\bar{R}^2 = .9327$$

APPENDIX H

THE CHOICE OF A VARIABLE TO REPRESENT PHYSICIANS INCOME

The income of a physician in the United States is certainly an attractive aspect of the profession. That the number of people entering the profession will increase as its financial status improves is axiomatic, all other factors being equal.

Yet it proved quite difficult to quantify precisely the real income of a U.S. physician, given the assortment of single proprietorships, partnerships, and corporations that exist, and even more difficult to identify the alternative sources of income that an individual might consider in making his decision.

For the foreign physician, the financial attractiveness of practicing medicine in the United States can be represented in mathmatical terms as:

$$1) \qquad \frac{S_{US}}{CPI_{US}} - \frac{S_F}{CPI_F}$$

where S_{US} is the median salary of a physician in the U.S. in nominal dollars, S_F is similarly the median salary (in U.S. dollars) of a physician in a foreign country, and both are adjusted by the nation's Consumer Price Index, CPI_{US} and CPI_F.

Yet the development of the variable in this form soon proved infeasible, given the time frame of the present

project. As a consequence, it was determined to use nominal U.S. physician income as an approximation for the true variable. The justification for this decision is as follows:

The alternatives to using (1) are as follows:

2) $$S_{US}$$

or

3) $$\frac{S_{US}}{CPI_{US}}$$

Examining the rate of change over time for expressions 1-3 gives:

4) $$\frac{d}{dt}\left(\frac{S_{US}}{CPI_{US}} - \frac{S_F}{CPI_F}\right) = \frac{\dot{S}_{US}}{CPI_{US}} - \frac{S_{US}\ C\dot{P}I_{US}}{CPI_{US}^2} - \frac{\dot{S}_F}{CPI_F} + \frac{S_F\ C\dot{P}I_F}{CPI_F^2}$$

5) $$\frac{d}{dt}\left(S_{US}\right) = \dot{S}_{US}$$

6) $$\frac{d}{dt}\left(\frac{S_{US}}{CPI_{US}}\right) = \frac{\dot{S}_{US}}{CPI_{US}} - \frac{S_{US}\ C\dot{P}I_{US}}{CPI_{US}^2}$$

The error of the two approximations in terms of deviation from the desired measure (1) can be demonstrated by the difference between the rates of change. For nominal dollars, this difference is (4) - (5), which is:

7) $$\frac{d}{dt}\left(\frac{S_{US}}{CPI_{US}} - \frac{S_F}{CPI_F}\right) - \frac{d}{dt}\left(S_{US}\right)$$
$$= \frac{\dot{S}_{US}}{CPI_{US}} - \frac{S_{US}\ C\dot{P}I_{US}}{CPI_{US}^2} - \frac{\dot{S}_F}{CPI_F} + \frac{S_F C\dot{P}I_F}{CPI_F^2} - \dot{S}_{US}$$

For real dollars, subtracting (6) from (4) yields:

8) $$\frac{d}{dt}\left(\frac{S_{US}}{CPI_{US}} - \frac{S_F}{CPI_F}\right) - \frac{d}{dt}\left(\frac{S_{US}}{CPI_{US}}\right) = \frac{S_F\ \dot{CPI}_F}{{CPI_F}^2} - \frac{\dot{S}_F}{CPI_F}$$

The difference in the error between these two terms, (7) - (8), becomes:

9) $$\frac{\dot{S}_{US}}{CPI_{US}} - \frac{S_{US}\ \dot{CPI}_{US}}{{CPI_{US}}^2} - \dot{S}_{US}$$

and factoring yields:

10) $$\dot{S}_{US}\left(\frac{1}{CPI_{US}} - 1\right) - \frac{S_{US}\ \dot{CPI}_{US}}{{CPI_{US}}^2}$$

In times of inflation, CPI_{US} and S_{US} will always be positive in sign and increasing, and CPI_{US} will be greater than or equal to 1. Thus expression (10) must be nonpositive in value.

If the common terms in expressions (7) and (8) are positive in value, then the nominal dollar approximation might be a better estimator, inasmuch as the addition of nagative terms would tend to bring the value of the approximation closer to the value of the true variable. The common terms are:

11) $$\frac{S_F\ \dot{CPI}_F}{{CPI_F}^2} - \frac{\dot{S}_F}{CPI_F},$$

which becomes by factoring:

12) $$\frac{S_F}{CPI_F}\left(\frac{\dot{CPI}_F}{CPI_F} - \frac{\dot{S}_F}{S_F}\right)$$

This expression is only positive in value for certain ranges of the variables. For instance, if no inflation exists then $CPI_F = 1$ and $\dot{CPI}_F = 1$ and $\dot{CPI}_F = 0$, so the expression reduces to $-\dot{S}_F$, positive only when nominal foreign salaries are decreasing. If the rate of increase in the Consumer Price Index exceeds the rate of increase in income, i.e., when $\frac{\dot{CPI}_F}{CPI_F} - \frac{\dot{S}_F}{S_F} > 0$, then the expression is positively valued. But even when (12) is positive, real dollars is still a better estimator if

$$\left|\dot{S}_{US}\frac{1}{CPI_{US}} - 1\right| - \frac{S_{US}\,\dot{CPI}_{US}}{CPI_{US}^{2}}\Bigg| < 2\left|\frac{S_F}{CPI_F}\left(\frac{\dot{CPI}_F}{CPI_F} - \frac{\dot{S}_F}{S_F}\right)\right| ,$$

since the positive terms would then create an even greater error in approximating the time variable.

But between these extremes there exists a substantial range of values for which nominal dollars is the better proxy for this income relationship. In developing the variable POOL, both nominal and real income were tested, and nominal income consistently performed better with respect to R^2 and t- statistic values. Nominal income was therefore used as the income variable in the foreign physicians portion of this study. Analogously, the selection of an income indicator for use in equation (4) was severely limited by the lack of available data. Ideally alternative income that potential physicians might earn in other occupations should be subtracted from physicians income and deflated by the Consumers Price Index (CPI). This would yield a difference in real terms which would represent the

potential gain to a student by choosing the field of medicine. But the alternative vocations that future physicians might choose are not clear. In dealing with an aggregate model the whole range of alternatives cannot be completely specified. The possible alternatives for which data was available were again real and nominal income. Both of these indicators were examined analytically in order to determine which would yield more realistic results. The equations which follow comprise this analysis. The method is similar to that used in examining which of these indicators to use in regard to foreign physicians.

(13) $$Y_1 = \frac{PI-AI}{CPI}$$

(14) $$Y_2 = \frac{PI}{CPI}$$

(15) $$Y_3 = PI$$

Equation (13) is the desired indicator while (14) and (15) are the available alternatives.

(16) $$\frac{d}{dt}(Y_1) = \frac{\dot{PI}}{CPI} - \frac{\dot{AI}}{CPI} - \frac{PI\ \dot{CPI}}{(CPI)^2} + \frac{AI\ \dot{CPI}}{(CPI)^2}$$

(17) $$\frac{d}{dt}(Y_2) = \frac{\dot{PI}}{CPI} - \frac{PI\ \dot{CPI}}{(CPI)^2}$$

(18) $$\frac{d}{dt}(Y_3) = \dot{PI}$$

Equations (16), (17), and (18) are the partial derivatives of all three indicators with respect to time.

$$(19) \qquad \frac{\mathrm{AI}\ \dot{\mathrm{CPI}}}{(\mathrm{CPI})^2} - \frac{\mathrm{AI}}{\mathrm{CPI}} = \frac{\mathrm{AI}}{\mathrm{CPI}}\left(\frac{\dot{\mathrm{CPI}}}{\mathrm{CPI}} - \frac{\dot{\mathrm{AI}}}{\mathrm{AI}}\right)$$

$$(20) \qquad \frac{\mathrm{AI}\ \dot{\mathrm{CPI}}}{(\mathrm{CPI})^2} - \frac{\dot{\mathrm{AI}}}{\mathrm{CPI}} + \frac{\dot{\mathrm{PI}}}{\mathrm{CPI}} - \frac{\mathrm{PI}\ \dot{\mathrm{CPI}}}{(\mathrm{CPI})^2} - \dot{\mathrm{PI}}$$

Equation (19) is the difference between equations (16) and (17) while equation (20) is the difference between (16 and (18)

$$(21) \qquad D = \frac{\dot{\mathrm{PI}}}{\mathrm{CPI}} - \frac{\mathrm{PI}\ \dot{\mathrm{CPI}}}{(\mathrm{CPI})^2} - \dot{\mathrm{PI}} = \dot{\mathrm{PI}}\left(\frac{1}{\mathrm{CPI}} - 1\right) - \frac{\mathrm{PI}\ \dot{\mathrm{CPI}}}{(\mathrm{CPI})^2}$$

Equation (21) is the difference between equations (19) and (20). If equation (19) is positive and equation (21) is negative the analysis would indicate that nominal rather than real would be the more appropriate income variable.

$$(22) \qquad \frac{\mathrm{AI}}{\mathrm{CPI}}\left(\frac{\dot{\mathrm{CPI}}}{\mathrm{CPI}} \geq \frac{\dot{\mathrm{AI}}}{\mathrm{AI}}\right)$$

If equation (22) is true equation (19) will be positive. Thus if the percentage change in CPI over time is greater than the percentage change in alternative income equation (19) will be positive. Due to the lack of data the conditions making equation (22) true must be assumed.

Assuming physicians income is growing with time and that CPI is increasing with time equation (21) will be negative.

The following equations which compare the results when estimating equations (2), (2A), (2B), and (4) of the model using both nominal and real income support the hypothesis that nominal income is the better indicator. In all cases examined the adjusted R^2 was highest when using nominal income.

Alternative Specifications of Model Equation (2),(2A),(2b),(4)

EQUATION (2)

$$\begin{array}{lllll} \text{POOL}_t = & 5914.46 & + 0.908\ \text{NOMINAL}_{t-3} & - 257.81\ \text{PASS}_{t-2} & \bar{R}^2 = .9538 \\ & (4969.55) & (0.063) & (105.33) & \\ & [1.19] & [14.38] & [2.44] & \end{array}$$

$$\begin{array}{lllll} \text{POOL}_t = & -3177.22 & + 1.44\ \text{REAL}_{t-3} & - 469.74\ \text{PASS}_{t-2} & \bar{R}^2 = .9125 \\ & (7074) & (0.143) & (139.40) & \\ & [0.45] & [10.09] & [3.37] & \end{array}$$

$$\begin{array}{llll} \text{POOL}_t = & 0.954\ \text{NOMINAL}_{t-3} & - 141.402\ \text{PASS}_{t-2} & \bar{R}^2 = .9521 \\ & (0.051) & (39.822) & \\ & [18.472] & [3.55] & \end{array}$$

$$\begin{array}{llll} \text{POOL}_t = & 1.41\ \text{REAL}_{t-3} & - 522.537\ \text{PASS}_{t-2} & \bar{R}^2 = .9273 \\ & (0.099) & (79.804) & \\ & [14.16] & [6.54] & \end{array}$$

$$\begin{array}{lllll} \text{POOL}_t = & 10081.66 & + 0.679\ \text{NOMINAL}_t & - 308.77\ \text{PASS}_{t-2} & \bar{R}^2 = .9311 \\ & (6037.01) & (0.081) & (127.07) & \\ & [1.67] & [8.29] & [2.42] & \end{array}$$

$$\begin{array}{lllll} \text{POOL}_t = & -5764.98 & + 1.39\ \text{REAL}_t & - 486.46\ \text{PASS}_{t-2} & \bar{R}^2 = .8672 \\ & (11672.34) & (0.32) & (174.75) & \\ & [0.49] & [4.22] & [2.78] & \end{array}$$

$$\begin{array}{lllll} \text{POOL}_t = & 4748.30 & + 0.908\ \text{NOMINAL}_{t-3} & - 230.50\ \text{PASS}_t & \bar{R}^2 = .9462 \\ & (5547.80) & (0.087) & (108.40) & \\ & [0.85] & [10.42] & [2.12] & \end{array}$$

$$\begin{array}{lllll} \mathrm{POOL}_t = & -4645.93 & + 1.347\ \mathrm{REAL}_{t-3} & - 353.07\ \mathrm{PASS}_t & \bar{R}^2 = .8929 \\ & (8523.16) & (0.151) & (161.15) & \\ & [0.54] & [8.9] & [2.1] & \end{array}$$

$$\begin{array}{lllll} \mathrm{POOL}_t = & 19841.04 & + 0.692\ \mathrm{NOMINAL}_t & - 589.05\ \mathrm{PASS}_t & \bar{R}^2 = .9137 \\ & (7601.73) & (0.074) & (156.20) & \\ & [2.61] & [9.29] & [3.77] & \end{array}$$

$$\begin{array}{lllll} \mathrm{POOL}_t = & 5990.72 & + 1.262\ \mathrm{REAL}_t & - 676.61\ \mathrm{PASS}_t & \bar{R}^2 = .8971 \\ & (9564.41) & (0.150) & (166.82) & \\ & [0.62] & [8.38] & [4.05] & \end{array}$$

EQUATION (2A)

$$\begin{array}{lll} \mathrm{FIRST}_t = & 0.369\ \mathrm{NOMINAL}_{t-1} & \bar{R}^2 = .8271 \\ & (0.012) & \\ & [30.246] & \end{array}$$

$$\begin{array}{lll} \mathrm{FIRST}_t = & 0.382\ \mathrm{REAL}_{t-1} & \bar{R}^2 = .6677 \\ & (0.017) & \\ & [21.66] & \end{array}$$

$$\begin{array}{llll} \mathrm{FIRST}_t = & 334.32 & + 0.359\ \mathrm{NOMINAL}_{t-1} & \bar{R}^2 = .8144 \\ & (1514.69) & (0.045) & \\ & [0.220] & [7.90] & \end{array}$$

$$\begin{array}{llll} \mathrm{FIRST}_t = & -7706.72 & + 0.620\ \mathrm{REAL}_{t-1} & \bar{R}^2 = .7704 \\ & (2859.95 & (0.089) & \\ & [2.69] & [6.92] & \end{array}$$

$$\text{FIRST}_t = 0.338 \text{ NOMINAL}_t \qquad \bar{R}^2 = .7300$$

(0.016)

[20.709]

$$\text{FIRST}_t = 0.380 \text{ REAL}_t \qquad \bar{R}^2 = .6742$$

(0.026)

[14.43]

EQUATION (2B)

$$\text{RESDUE}_t = 8763.05 + 0.401 \text{ NOMINAL}_{t-1} - 314.29 \text{ PASS}_{t-1}$$

$$\bar{R}^2 = .9344$$

(3335.59) (0.035) (69.318)

[2.62] [11.21] [4.53]

$$\text{RESDUE}_t = 1628.60 + 0.675 \text{ REAL}_{t-1} - 346.8112 \text{ PASS}_{t-1}$$

$$\bar{R}^2 = .8798$$

(5206.03) (0.085) (92.99)

[0.312] [7.94] [3.72]

$$\text{RESDUE}_t = 8309.70 + 0.367 \text{ NOMINAL}_t - 295.25 \text{ PASS}_{t-1}$$

$$\bar{R}^2 = .9116$$

(3929.65) (0.038) (81.338)

[2.12] [9.49] [3.63]

$$\text{RESDUE}_t = -321.40 + 0.667 \text{ REAL}_t - 309.12 \text{ PASS}_{t-1} \qquad \bar{R}^2 = .8240$$

(6695.62) (0.106) (115.07)

[0.04] [6.26] [2.68]

$$\text{RESDUE}_t = 1461.23 + 0.364\ \text{NOMINAL}_{t-1} - 83.33\ \text{PASS}_t \qquad \bar{R}^2 = .9195$$

(3813.95) (0.070) (67.55)

[0.383] [5.17] [1.23]

$$\text{RESDUE}_t = -1774.77 + 0.706\ \text{REAL}_{t-1} - 293.92\ \text{PASS}_t \qquad \bar{R}^2 = .8199$$

(6646.87) (0.103) (127.77)

[0.26] [6.84] [2.30]

$$\text{RESDUE}_t = 6136.39 + 0.387\ \text{NOMINAL}_t - 266.97\ \text{PASS}_t \qquad \bar{R}^2 = .8900$$

(4654.80) (0.045) (95.65)

[1.31] [8.49] [2.79]

$$\text{RESDUE}_t = -1310.66 + 0.700\ \text{REAL}_t - 318.63\ \text{PASS}_t \qquad \bar{R}^2 = .8619$$

(6008.57) (0.094) (104.80)

[0.218] [7.40] [3.04]

EQUATION (4)

$$\text{APPLICANTS}_t = 7802.92 + 13.25(\text{NOMINAL}_t)^2 - 243.42\ \text{FSL}_t$$

$$\bar{R}^2 = .9739$$

(1925.69) (1.45) (97.13)

[4.05] [9.10] [2.51]

$$\text{APPLICANTS}_t = -3731.78 + 25.53(\text{REAL}_t)^2 - 229.73\ \text{FSL}_t$$

$$\bar{R}^2 = .9318$$

(5878.74) (5.54) (171.28)

[0.63] [4.60] [1.34]

EQUATION (4A)

$$\begin{array}{lllll} \text{APPLICANTS}_t = & 7384.99 & +\ 10.95 & (\text{NOMINAL}_t)^2 & \qquad \bar{R}^2 = .9660 \\ & (2760.10) & (1.25) & & \\ & [2.67] & [8.71] & & \end{array}$$

$$\begin{array}{lllll} \text{APPLICANTS}_t = & -350.31 & +\ 20.01 & (\text{REAL}_t)^2 & \qquad \bar{R}^2 = .9286 \\ & (5578.18) & (3.80) & & \\ & [0.06] & [5.25] & & \end{array}$$

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